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NOTES FOR STUDENTS

Species hybrids.—According to one definition of species, which maintains that crossing is impossible beyond the species boundary, there can be no such thing as a species hybrid. The experience of many breeders, however, shows numerous cases of successful crossing between forms that are commonly regarded as distinct species. As might well be expected, many of these species crosses exhibit peculiarities, and it is of considerable theoretical interest to analyze them. In this connection it is enlightening to consider some of the ideas which were suggested to EAST and HAYES³ by their experiments on hybrid vigor, and which may be freely interpreted as follows. As the width of a cross increases, four characteristic stages are encountered. (1) Very narrow crosses commonly bring little more than the redistribution of a few Mendelian characters. (2) Wider crosses, involving a considerable number of Mendelian factors, in many plants will produce a first hybrid generation which is characterized by a certain amount of hybrid vigor, the amount increasing with the width of the cross. (3) A point is reached where the fertility of the hybrid falls off, and at a certain width of cross perfectly sterile hybrids may be expected. It is interesting that hybrid vigor commonly continues to increase even though fertility decreases. Here loss in "efficiency" in the reproductive system is distinctly not accompanied by loss in efficiency in vegetative development. This peculiarity is clarified by the following idea. Wide crosses involve the fusion of relatively "inharmonious" gametes, which might be expected to produce disturbances in the ontogeny of the resulting individual. The grosser mechanism which regulates vegetative development can evidently weather such disturbances, while the more finely balanced mechanism of gamete formation is upset. (4) Finally, in the widest crosses, even vegetative development is impaired, and poorly developed hybrids result, a point eventually being reached where crosses are entirely unsuccessful.

Species crosses in *Nicotiana*, made by GOODSPEED and CLAUSEN,⁴ and by EAST,⁵ and the wheat-rye crosses of JESENKO⁶ gave results which, although not identical, were significantly similar. All seem to be of the third type, the first generation hybrids being vigorous but almost sterile. The nature of this sterility is pictured in the following theory, which was proposed by BABCOCK and CLAUSEN, and supported and somewhat enlarged by EAST. Two *Nicotiana* species, *A* and *B*, each having a haploid chromosome number of 24, are crossed

³ EAST, E. M., and HAYES, H. K., Heterozygosis in evolution and in plant breeding. U. S. Dept. Agric. Bur. Plant Ind. Bull. 243. pp. 58. 1912.

⁴ GOODSPEED, T. H., and CLAUSEN, R. E., Mendelian factor differences versus reaction-system contrasts in heredity. Amer. Nat. 51:31-46, 92-101. 1916.

⁵ EAST, E. M., A study of partial sterility in certain hybrids. Genetics 6:311-365. figs. 17. 1921.

⁶ See BABCOCK, E. B., and CLAUSEN, R. E., Genetics in relation to agriculture New York. 1918 (p. 238).

to produce a hybrid which contains 24 chromosomes from parent *A* and 24 from parent *B*. Reduction division by this hybrid should produce gametes of numerous types, ranging from those which would possess the 24 chromosomes of the *A* parent and none of the *B* chromosomes, to the other extreme in which the reverse would be true. It is assumed that gametes in the intermediate condition, with a liberal mixture of *A* and *B* chromosomes, fail to develop. "Any gamete containing elements derived from both systems would give a reaction system subject to profound disturbances incident upon the inharmonious relations set up" between the *A* and *B* elements. In consequence the only gametes which successfully develop are such as contain all or almost all of the *A* chromosomes, or all or almost all of the *B* chromosomes. This hypothesis of selective survival of the gametes produced by the F_1 species hybrid is supported by the following very striking facts. Back crosses with either parent result in the production of a relatively much higher number of forms identical or almost identical with that parent than would otherwise be expected. Also, in the scanty F_2 generation which it is sometimes possible to obtain, many more individuals appear which are identical or almost identical with the original grandparents (*A* and *B*) than would otherwise be expected.

SAX⁷ arranges the species of *Triticum* in three groups, characterized by haploid chromosome numbers of 7, 14, and 21 respectively. Crossing within the groups produces fertile hybrids, but crossing between the groups results in more or less sterile hybrids. It is noteworthy that the F_1 endosperms are well developed in the fertile crosses, but shriveled in those crosses which are to produce sterile or partially sterile F_1 plants. In all cases, however, hybrid vigor appears in the vegetative parts of the F_1 plants. Evidently endosperm development as well as gametogenesis is sensitive to the disturbances resulting from the union of "inharmonious" gametes. The F_2 results of SAX,⁸ however, appear not to agree with the ideas of the other investigators, since in this generation no greater sterility appears in the intermediates than in the segregates resembling the grandparents. Ecologists as well as geneticists will be interested in the natural law which is suggested by this work of SAX. In a group of species of which the chromosome numbers vary in multiples of an original basic number, adaptability varies directly with the chromosome count. Thus the 21 chromosome wheats are the most adaptable, and the 7 chromosome wheats are the least adaptable.—M. C. COULTER.

Fusarium resistant cabbage.—The selection of *Fusarium* resistant strains of cabbage is being continued at the Wisconsin Experiment Station by JONES⁹

⁷SAX, KARL, Sterility in wheat hybrids. I. Sterility relationships and endosperm development. *Genetics* 6:399-416. 1921.

⁸SAX, KARL, Chromosome relations in wheat. *Science* 54:413-415. 1921.

⁹JONES, L. R., WALKER, J. C., and TISDALE, W. B., *Fusarium* resistant cabbage. *Wis. Agric. Exp. Sta. Res. Bull.* 48. 1-34. figs. 10. 1920.